In the table above, two numbers such as "1+2," indicate that one-tenth of the sky was covered by the form indicated, and that there is every reason to believe that there were two-tenths more of the same cloud form behind a lower sheet, which at the time of the observation actually covers those two-tenths of the sky. "oo" indicates that the covering is less than about 7 per cent.

It will be noted in certain instances that the total sky cover exceeds the sum of the individual cloud covers indicated. In these cases, there may be two or three forms covering only 5 per cent or less of the sky each, which altogether would make a tenth. It would be inaccurate to designate any one of these forms as covering a tenth of the sky, in order to make the total conformto the total cover.

THE REFLECTING POWER OF CLOUDS.

By L. B. ALDRICH.

(Smithsonian Misc. Col., vol. 69, No. 10, Washington, 1919.)

Measurements of sky brightness were made by the author in cooperation with officers and men of the balloon school of the Army at Arcadia, Cal., on September 17, 1918. They may be considered a continuation with improved facilities of the measurements already discussed in the Annals of the Astrophysical Observatory, Volume II. The author's summary follows:

SUMMARY.

A pyranometer suspended below the basket of an Army observation balloon was used to measure the reflecting power of a level cloud surface practically filling a hemisphere of solid angle. Over 100 determinations were made. The solar air masses ranged from 2.8 to 1.2, and the sky above was cloudless and very clear. A mean value of 78 per cent is obtained. No change of total reflection depending on solar zenith distance is apparent within a range of zenith distance from 33° to 69°. A value of 43 per cent for the albedo of the earth is obtained by revision of the earlier value of Abbot and Fowle (Annals, Vol. II, p. 162) which depended on a lower value of cloud reflection based on observations over but a small part of a hemisphere.—H. H. K.

AN IMPROVEMENT IN THE POLE STAR RECORDER.

By B. C. KADEL.

[Dated: Weather Bureau, Washington, Apr. 3, 1919.]

An instrument known as the pole star recorder has been recently completed in the Instrument Division of the Weather Bureau for use at the Weather Bureau observatory at the University of Chicago (see fig. 1). The pole star is not at the true north pole of the celestial sphere, but is about 1¼ degrees from it, and therefore appears to move each day about the true pole in a circular path whose diameter is about 2½ degrees. If a camera is pointed toward Polaris, and the shutter is opened after dark and closed before daylight next morning, we shall find on the sensitized plate or film a curved line made by the light from the pole star, provided the sky about the star was clear. When clouds are present all night the plate will be blank, and when the night is one of varying cloudiness, a broken curved line will result (see figs. 6, 7, and 8).

It is evident, therefore, that a camera offers a fairly reliable means of recording cloudiness at night without any complicated mechanical parts, although the portion of the sky about Polaris may not always represent the condition of the sky as a whole. Prof. E. C. Pickering, of Harvard University, is said to have been the first to employ the device, and Mr. S. P. Fergusson [1] published in 1905 a description of an improved form.

Several years ago Prof. C. F. Marvin designed a clock attachment for opening and closing the shutter of the camera at a predetermined time, and provided a circular metallic disk or dial with time graduations cut through it, so that by interposing the disk between the sensitized plate and daylight for a fraction of a second, the time scale might be printed photographically. Orientation of the graduated disk was accomplished each day by reference to the almanac, and it was found that the men assigned to the work were quite liable to error and confusion in setting the disk.

The improvement to be described is directed to rendering the orientation of the disk a simple operation, and particularly to making the observer independent of the almanac. The disk (figs. 2 and 3), with the time scale engraved upon it as intended to be reproduced upon the sensitized film, is built into a rotating circular brass frame upon whose periphery is formed a cogwheel with 365 teeth, one tooth for each day in the year. A worm wheel that meshes with the 365-toothed wheel is turned by means of a small thumb screw attached to a shaft that projects within reach of the observer (see fig. 2). The entire device is built into a frame modeled after a standard photographic plate holder.

When the disk has been once properly oriented, it is required merely to turn the thumb screw one complete revolution each day to advance the time scale 1/365th of a revolution, and thus bring it into proper relation to the star trail. The record actually made by Polaris in sidereal time may then be read off directly in mean solar time of a standard meridian.

In order that the observer may be able to make the initial setting without reference to the almanac, there has been engraved on the rotating dial opposite selected hours the date on which Polaris culminates at that particular hour (see fig. 3.) When the particular hour mark mentioned coincides with an arrow engraved on the nonrotating part of the device at the position corresponding to upper culmination, the dial is approximately correct for the date indicated, probably within the limits of accuracy of the instrument. Final adjustment to the actual date desired is accomplished by turning the thumb screw the required number of revolutions.

A removable circular section of clear glass has been set into the central portion of the space within the time dial, to provide a means of identification of the record. The glass is first smoked, after which the date is stamped on with an uninked rubber stamp, which removes the soot, so that the light may shine through.

The entire time-scale device is inserted between the sensitized film or plate and the lens of the camera in the

[1] Fergusson, S. P.: "The Automatic Polar Star Light Recorder"; Quart. Jour. Roy. Meteorological Soc., 31, 1905, p. 309-313, and Amer. Meteorological Jour., June, 1894, p. 62-64.

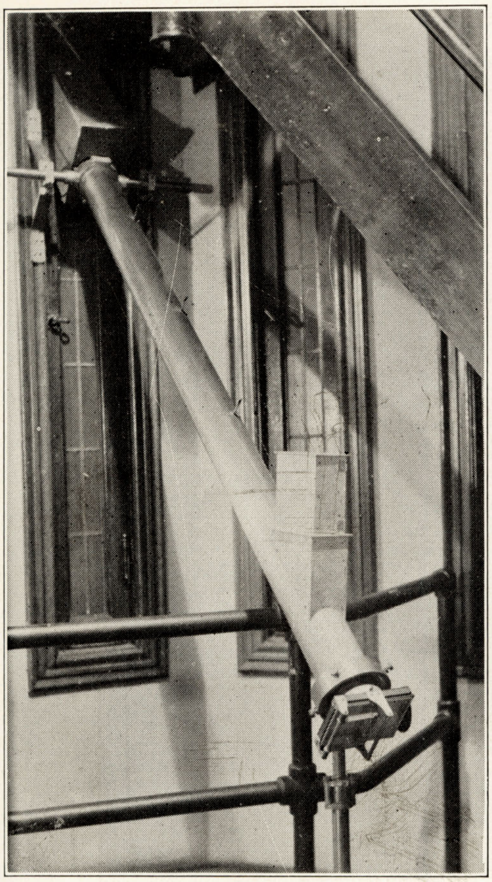

FIG. 1.—Pole Star recorder, complete, as installed at a north window.

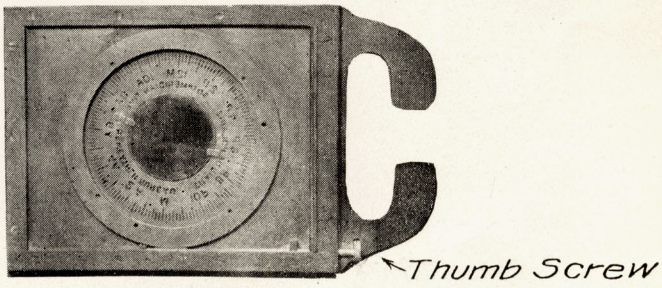

FIG. 2.—Time-scale printing device.

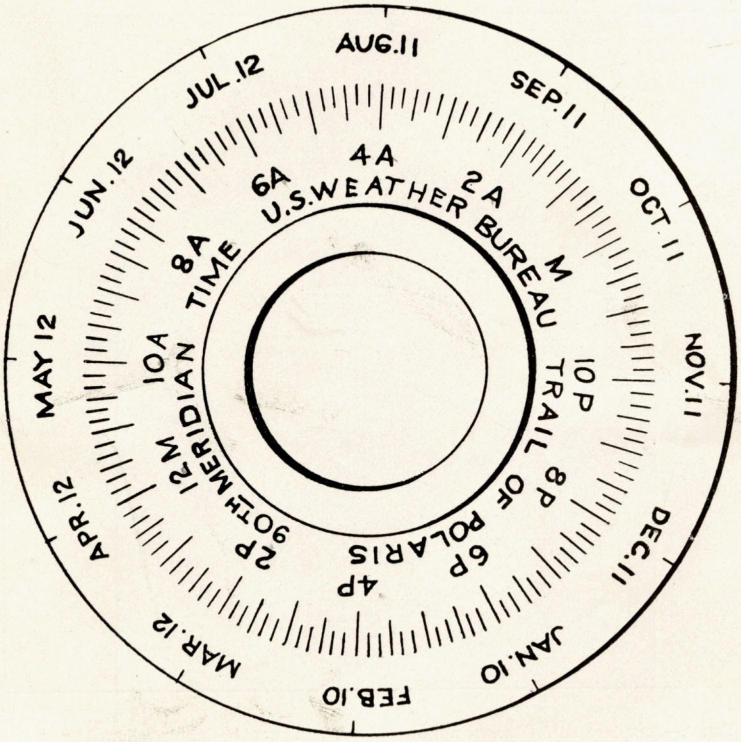

FIG. 3.—Time-scale printing device. Dates and coincidence lines at outer rim are engraved on the plate. Other data are cut through the plate.

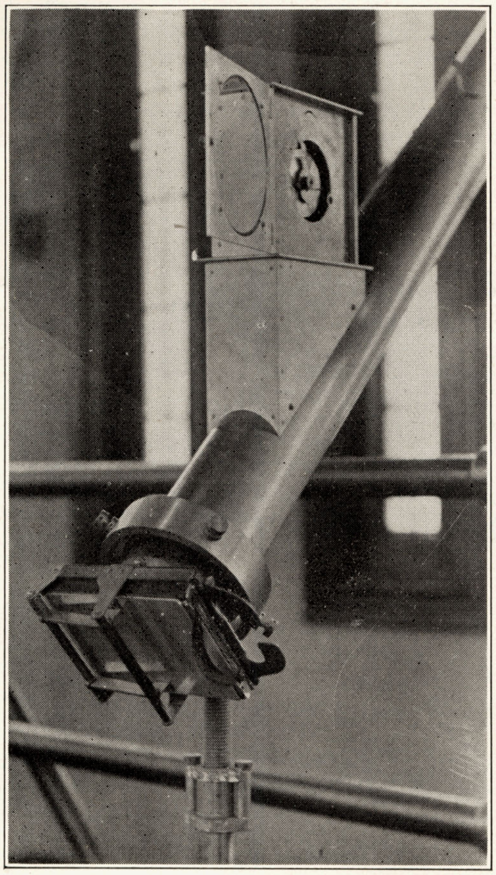

FIG. 4.—Time-scale printing device shown in position in front of plate holder.

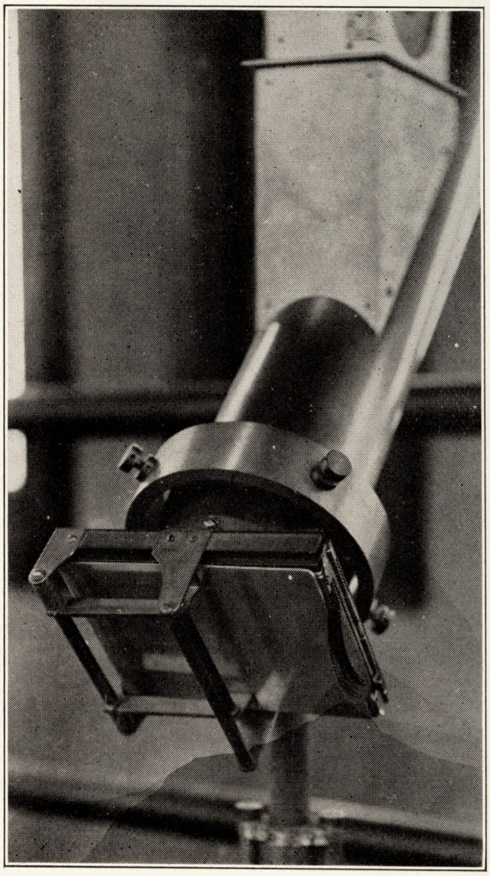

FIG. 5.—Time-scale printing device removed. Camera now ready for night's record.

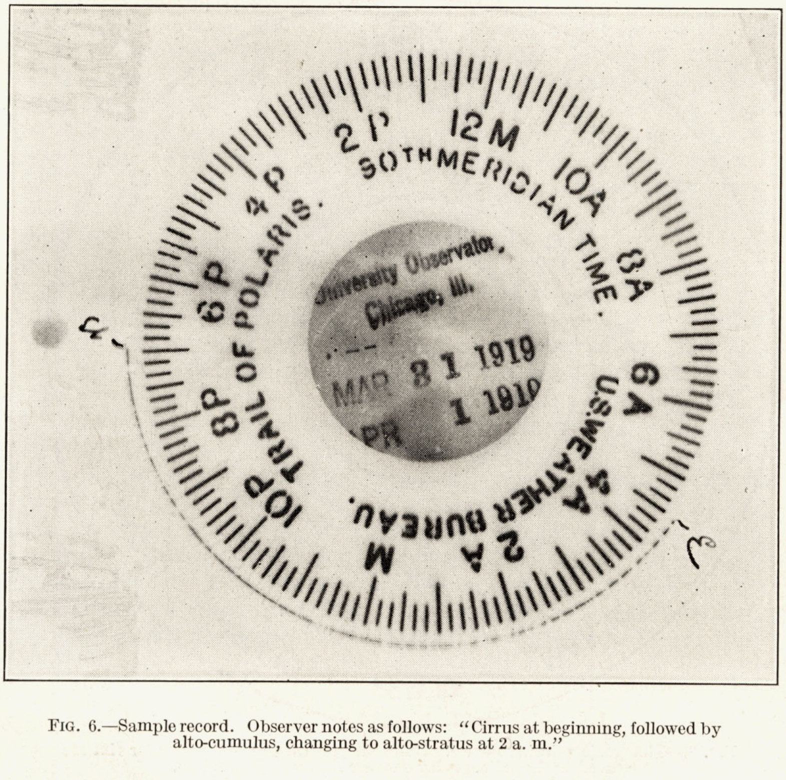

FIG. 6.—Sample record. Observer notes as follows: "Cirrus at beginning, followed by alto-cumulus, changing to alto-stratus at 2 a. m."

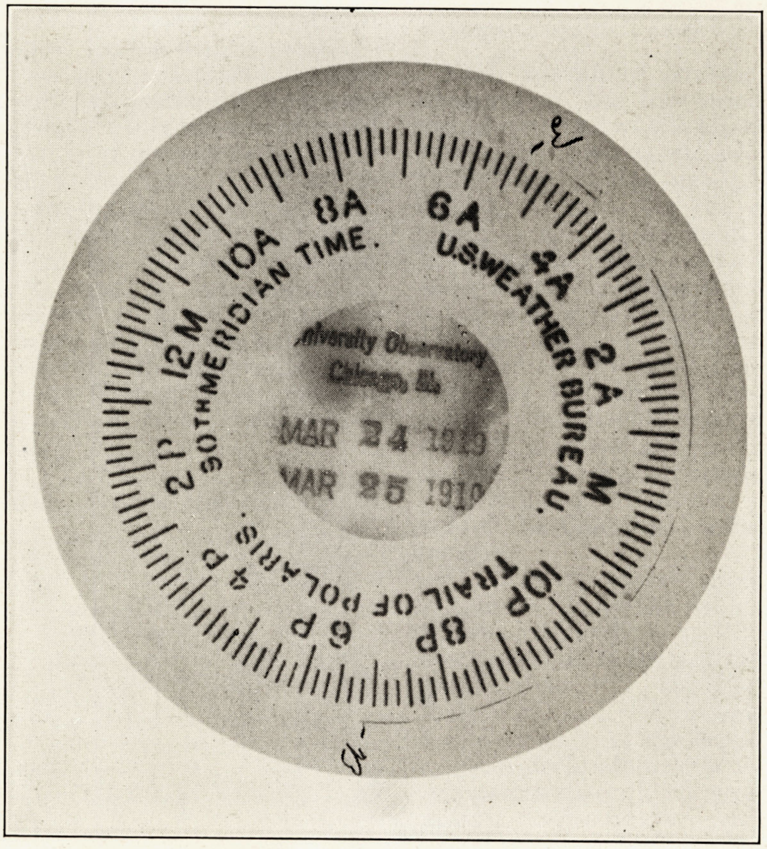

FIG. 7.—Sample record. Observer notes as follows: "Cirrus and cirro-stratus, with patches of alto-stratus."

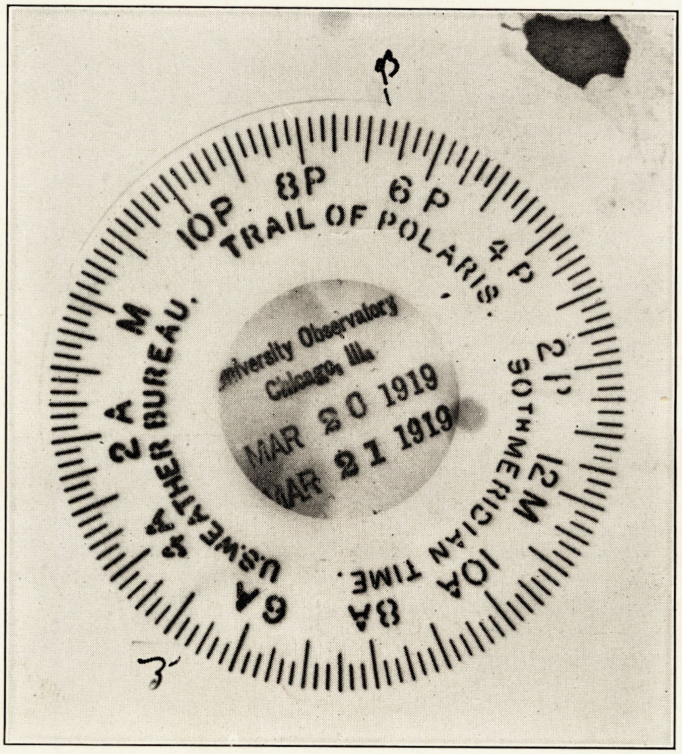

FIG. 8.—Sample record. Observer notes as follows: "Fast-moving cumulus and alto-stratus."

daytime (fig. 4), and the shutter opened for a fraction of a second, after which the time-scale device is withdrawn (fig. 5), leaving the camera clear for the night's record.

The time to open the shutter after sunset and the time to close it before sunrise in order to obtain the maximum length of record without fogging the film has been worked out as follows: An examination of exposures made by Mr. A. J. Weed during preliminary trials of the instrument discloses that the films are fogged on full moonlight nights, but not to a sufficient extent to impair the record. It may therefore be considered safe to open the shutter just at the time twilight is equal to full moonlight. Measurements made by Thiessen[1] show that this occurs when the sun is approximately 10½ degrees below the horizon. Using the formula given in the same article, the time (90th meridian time) at Chicago when twilight is equal to full moonlight has been computed as follows:

Time when the sun's altitude is −10° 30′ at Chicago.

		Apparent time.		Equation of time. (minutes.)	Including −10 minutes to reduce Chicago to 90th meridian time.	Standard time 90th meridian.	
		(p. m.).	(a. m.).			Open shutter (p. m.).	Close shutter (a. m.).
	1899.						
Jan.	1	5:34	6:26	+4	−6	5:28	6:20
	10	5:38	6:22	+8	−2	5:36	6:20
	20	5:45	6:15	+11	+1	5:46	6:16
Feb.	1	5:56	6:04	+14	+4	6:00	6:08
	10	6:07	5:53	+14	+4	6:11	5:57
	20	6:18	5:42	+14	+4	6:22	5:46
Mar.	1	6:30	5:30	+12	+2	6:32	5:32
	10	6:42	5:18	+10	0	6:42	5:18
	20	6:57	5:03	+7	−3	6:54	5:00
Apr.	1	7:14	4:46	+4	−6	7:08	4:40
	10	7:28	4:32	+1	−9	7:19	4:23
	20	7:43	4:17	−1	−11	7:32	4:06
May	1	7:58	4:02	−3	−13	7:45	3:49
	10	8:11	3:49	−4	−14	7:57	3:35
	20	8:24	3:36	−4	−14	8:10	3:22
June	1	8:35	3:25	−2	−12	8:23	3:13
	10	8:41	3:19	−1	−11	8:30	3:08
	20	8:43	3:17	+1	−9	8:34	3:08
July	1	8:41	3:19	+4	−6	8:35	3:13
	10	8:36	3:24	+5	−5	8:31	3:19
	20	8:27	3:33	+6	−4	8:23	3:29
Aug.	1	8:18	3:42	+6	−4	8:14	3:38
	10	8:00	4:00	+5	−5	7:55	3:55
	20	7:45	4:15	+3	−7	7:38	4:08
Sept.	1	7:28	4:32	0	−10	7:18	4:22
	10	7:15	4:45	−3	−13	7:02	4:32
	20	7:00	5:00	−6	−19	6:41	4:41
Oct.	1	6:45	5:15	−10	−20	6:25	4:55
	10	6:32	5:28	−13	−23	6:09	5:05
	20	6:19	5:41	−15	−25	5:54	5:16
Nov.	1	6:05	5:55	−16	−26	5:30	5:29
	10	5:55	6:05	−16	−26	5:29	5:39
	20	5:46	6:14	−14	−24	5:22	5:50
Dec.	1	5:38	6:22	−11	−21	5:17	6:01
	10	5:34	6:26	−7	−17	5:17	6:09
	20	5:32	6:28	−2	−12	5:20	6:16

Valuable suggestions and assistance in designing and constructing the device have been given by Messrs. S. P. Fergusson, R. N. Covert, A. J. Weed, Julius J. Martin, and others of the Instrument Division force.

Working drawings may be obtained at actual cost of blue prints by application addressed to Chief of the Weather Bureau.

[1] Kimball, Herbert H., The Duration and Intensity of Twilight. MONTHLY WEATHER REVIEW, vol. 44, November, 1916, p. 614-620.

THE DURATION OF MOONLIGHT.

[Reprinted from Meteorological Office Circular No 18., Nov. 26, 1917, pp. 3-4.]

Prof. Alexander McAdie, director of the Blue Hill Observatory, has forwarded a specimen of a moonlight record obtained at the observatory by means of a Campbell-Stokes sunshine-recorder and a strip of photographic gaslight developing paper cut to fit the groove of the recorder suitable for the occasion. The whole of the record is colored uniformly gray by direct moonlight but along the center runs a black line, about 1 millimeter wide, which represents the effect of the moonlight which is focussed by the ball of the recorder upon the paper. This line is analogous to the burnt records caused by the sun, with the difference that the moonlight record is produced by the short actinic light rays from the moon, while the sun record is due to the long heat rays from the sun. This moonlight recorder thus finds its exact counterpart in the Jordan sunshine recorder.

Certain precautions will be necessary for the successful use of the Campbell-Stokes instrument as a moonlight recorder.

(1) The appropriate groove must be found for the day in question from the table of moon's declination in the Nautical Almanac or in Whitaker's Almanac. The summer groove is to be used when the moon's declination is greater than 9°N., the winter groove when it is greater than 9°S., and the equinoctial groove for intermediate declinations. As the moon passes through a complete cycle in declination once in a lunar month, whereas the sun passes through its cycle once a year, changes of the moon's declination are very rapid, and care will be required to change the groove when necessary. The range of the moon's declination is somewhat greater than that of the sun, but the ordinary sunshine recorder would probably just serve to obtain a complete set of moonlight records.

(2) The sensitive paper must be inserted not earlier than an hour after sunset and removed not later than an hour before sunrise; otherwise it will be completely fogged by daylight.

(3) The meridian position of the record may be indicated on the paper before it is removed from the groove by making a prick opposite the "noon" mark of the recorder. The time corresponding with this mark is the "Hour of moon's southing," and is given in the M. O. Calendar.

(4) The time scale of the moonlight recorder is a shade less open than that of the sun recorder, owing to the moon's motion in right ascension. If the length of the trace is measured on the scale provided for sunshine, the duration of moonlight may be found by adding 3 per cent to the measurement.

The observer who is interested in astronomy and the theory of the sunshine recorder will find in the use of his instrument as a moonlight recorder a very interesting and instructive exercise. If the recorder were used exclusively for moonlight recording the early rising entailed in summer by the necessity of removing the moonlight record before daybreak could be avoided by arranging for a suitable light-tight drop cover to be released at a pre-determined hour through the agency of an alarm clock.